U.S. DEPARTMENT OF ENERGY

Real World Design Challenge

The Nation's Innovation Engine: How America Competes

Background and Need

Global Competition is currently in a transformative stage. The United States has been strong and prosperous through many generations of hard work, visionary innovation and ingenuity, and a first rate education system. All this is changing. The United States must not only adapt, it must transform its education systems to lead.

The best investment the United States can make right now is in its education system. We need to provide students with the background and framework for competing differently and more effectively than the United States has ever competed before.

Technology and engineering education represents an area of strategic learning and preparation needed to support United States workforce needs in areas impacting economic and national security.

There are critical workforce needs that the United States faces in the areas of engineering and technology. A large percentage of the engineering workforce is eligible to retire and there are not enough students in the pipeline to satisfy the need. In all classified and many non-classified strategic jobs the United States needs to employ qualified U.S, citizens. Fifty-four percent of the aerospace science and technology (S&T) workforce is over 45 and 33% are eligible to retire today.[1] Currently, there are not sufficient numbers of students in the pipeline to replace them. Less than 10% of high school graduates pursue undergraduate degrees in engineering. Of the 10% who enter engineering, only about 50% earn a degree in engineering.[2] In recent years the enrollment numbers in engineering have dropped even farther.[3] The Department of Defense (DoD) employs approximately 67% of all federal scientists and engineers. Approximately 90% of all federal mechanical engineers are employed by the DoD.[4] Due to security requirements, these jobs can only be filled by U.S. citizens. This also true for companies with national security contracts. Aerospace Industries Association President and CEO, John Douglass stated that, "with $161 billion in sales…U.S. aerospace is a strategic industry in the nation's economy, homeland security, and national defense."[5]

If the U.S. does not have the human resources to satisfy these needs, U.S. national security will be at risk.

Throughout our nation's history, the skills and education of our workforce have been a major determinant of the standard of living. The 21st century has brought opportunities for most countries in the world to participate in the global knowledge economy. "Innovation will be the single most

[1] Druyun, D., *Defense Reform 2001, A Blueprint for Action: Final Report, DFI International* 2001, P. 7
[2] Chubin, *National Action Council for Minorities in Engineering Testimony to the Government-University-Industry Research Roundtable*, 2002
[3] Chapter 2 Highlights of *Science and Engineering Indicators 2006,* National Science Foundation, 2006
[4] Department of Defense Briefing, Virginia, December 2005.
[5] High Growth Industry Profile: Aerospace, DOL Website.

important factor in determining America's success through the 21st Century."[6] "Innovation fosters the new ideas, technologies, and processes that lead to better jobs, higher wages and a higher standard of living. For advanced industrial nations no longer able to compete on cost, the capacity to innovate is the most critical element in sustaining competitiveness. But the United States now finds itself at a potential inflection point—facing new realities that pose significant challenges to our global innovation leadership." [7]

A knowledge economy depends upon the development and use of technological tools/systems. The ability to create, innovate and continuously improve those tools/systems will differentiate between the leaders and the followers in a global knowledge economy. If the U.S. intends to lead, we need to ensure that we have a strong and secure workforce that includes sufficiently large numbers of engineers who innovate and create, technologists who develop practical applications, and technicians who maintain technological systems.

The pressures of continuous innovation in a global knowledge economy require a workforce that is more than technology literate and fluent. A continuously innovative workforce requires as a pipeline of *innovative thinkers* grounded in principles of design and the design process. All students need to become innovators grounded in principles of design and the design process, to ensure that a sufficiently large percentage of the 21st century workforce has innovative thinkers. Students also need to be prepared to operate in a global environment. Global Engineering prepares them to meet those challenges.

Real World Design Challenge

The Real World Design Challenge will begin addressing the United States workforce needs in the 2008-2009 pilot academic year by building the student/workforce pipeline in the participating states. This will expand as the Challenge grows within each state and eventually involves students in all fifty states and territories. As the Challenge grows each year new themes will be added exposing students to industry needs in many sectors. By providing access to industry-based tools, mentors from the U.S. Department of Energy National Laboratories, and software training for teachers, the Challenge aligns secondary education with 21st Century workforce needs and strengthens professional development for educators. Facilitated through a partnership between the Department of Energy, Parametric Technology Corporation (PTC), and state governments, the Real World Design Challenge is a prime example of how the government, private industry, and our educational system can work together to keep our workforce the best in the world.

A highly skilled engineering workforce is at the core of both our economic competitiveness and national security. Our National Laboratories possess scientific and engineering expertise beyond that of any other nation. The Real World Design Challenge will harness this expertise using web-based professional collaboration tools to break down the geographic limitation that has previously restricted student contact with experts. It will build and innovative workforce for the future by inspiring and engaging all students in STEM (Science, Technology, Engineering and Mathematics) education and by systematically highlighting the potential opportunities open to workers in scientific and engineering fields. Many students are already proficient in the types of high tech tools that allow our industry leaders to collaborate, and this proficiency will be focused on the Challenge, putting it to constructive use. Students too often dismiss what they learn in school as having no real world connection. But the Real World Design Challenge will excite students about what they learn in school because it will allow them to tackle real world problems, and see the difference their efforts can make in the future.

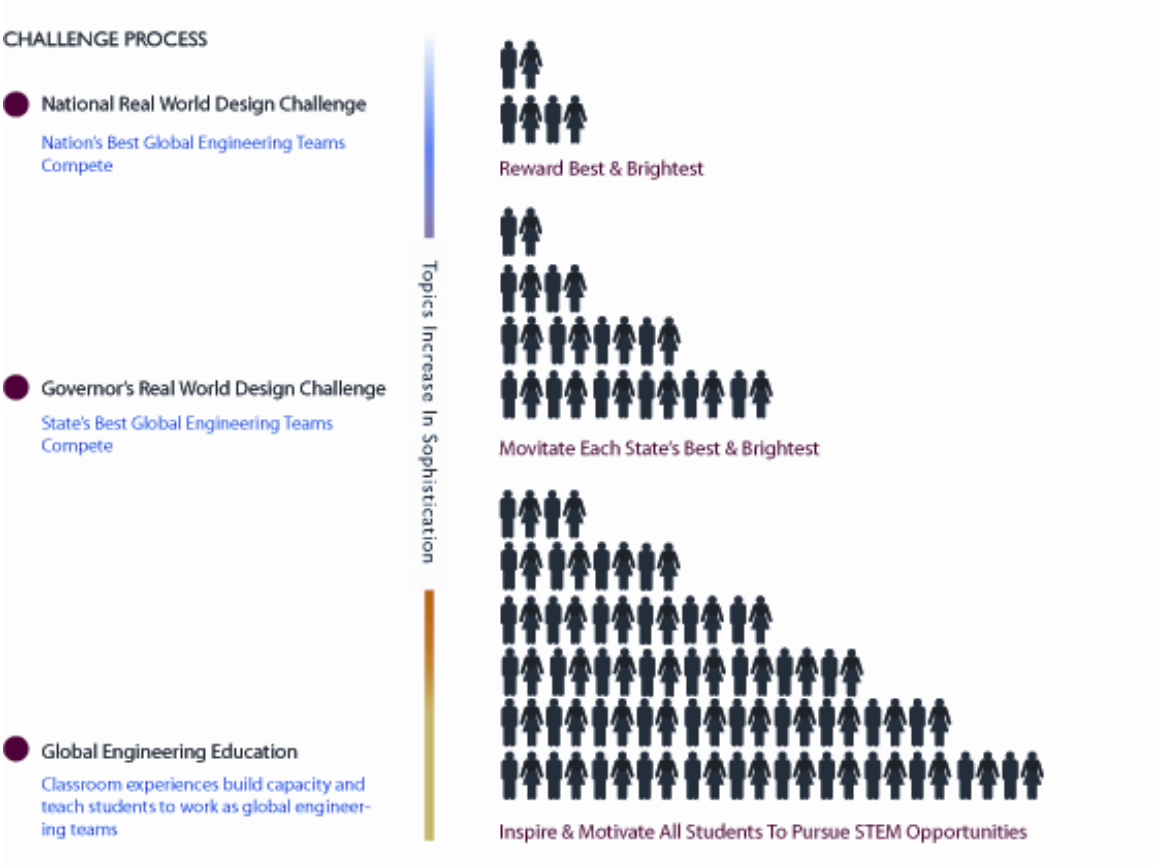
The Real World Design Challenge "bridges the needs of industry with the future of education." It teaches innovation, creativity, and collaboration using the expertise that industry has been

[6] *InnovateAmerica,* Council on Competitiveness, 2004, Washington, DC, P.5
[7] National Innovation Initiative, Council on Competitiveness, http://www.compete.org/nii/

perfecting for decades. With this real world approach to learning, we can keep our workforce strong, and ensure America's prosperity for the future.

The Goals of the Challenge are to (1) inspire and engage all students in STEM education and (2) systematically highlight the potential future workers in science and engineering fields.

Real World Design Challenge Process



Research and Promising Practices

The *United Kingdom* (UK) has been developing a Design and Technology program with great success. It is part of the national curriculum and is called the "CAD/CAM In Schools Programme". Much of the recent research in this area is from the UK. Currently 83% of the secondary schools in the UK use 3D Computer Aided (CAD) design software. CAD is one of the areas of study in Information Communication Technologies (ICT). Technology Education in the United States is not as far along in its development as its counterpart in the U.K. However, some groups have been trying to adapt the British model for use in the U.S.[8]

Higher Grades, Higher Motivation, Better Attendance, Lower Anti-Social Behavior

In the *United Kingdom*, students that used ICT had better attendance, higher grades and lower anti-social behavior. The schools showed an average increase in grade attainment of 16

[8] Todd, R. & P. Hutchinson, "The Transfer of Design and Technology (D&T) to the United States: A Case Study", The College of New Jersey, Ewing, NJ

percentage points from 1999 to 2003.[9] "Teachers widely reported that ICT was motivational because it enabled pupils to make improvements to the quality of their work…." "In some cases improved quality of work in a subject was more fundamentally identified, such as within Design and Technology where ICT was believed to impact directly on the processes involved in learning. Where ICT was fully embedded in subject teaching (as in the case with Design and Technology…) there appeared to be a related impact on pupil attainment at GCSE [General Certificate of Secondary Education, the national student assessment]." [10] "All head teachers interviewed believed that ICT had a positive effect on behavior in lessons, because it's use made pupils more committed to the learning task, allowed them to feel more in control and able to achieve more professional outcomes."[11]

Computer Aided Design Major Factor in Student Success

In the *United Kingdom* "Computer-aided design and manufacture is a major and influential development that has stimulated much successful work in ICT." The Report also states "…the most effective factor in developing the use of ICT in design and technology has been the provision of advanced 3D-CAD software."[12]

In the *United Kingdom*, the Design & Technology (D&T) has had a significant impact on the interest and achievement levels of girls in product design. National examination data for 2001show a significant difference between girls and boys pass rates in D& T. In 2000, 60 % of girls attained a grade of A to C, compared to 44 % of boys.

At Loughborough University in the U.K., researchers surveyed industrial design students at the university. They discovered that 70.4 % of students who had used 3D design software in secondary school to produce their A level D&T projects experienced significant benefits when they began studying industrial design at university.[13]

In a case study in *Massachusetts*, design and technology was shown to have a positive impact on math and science achievement with at risk students, enhances motivation and helps all students become technologically literate. In 2002, 70 Shawsheen Valley Technical High School students who were at risk of failing the math portion of the Massachusetts Comprehensive Assessment System (MCAS) attended a special summer program designed to help them learn the math portion of the required MCAS tests. The students were exposed to design modules, using 3D design software, to help them learn 32 math concepts. There was significant increase in Stanford Diagnostic math scores after participation in the program. Some 88.5% of the students showed overall growth (62 out of 70); and the performance of 15 % increased by at lest four grade levels.

Students Learn to Use and Apply Creativity, Imagination, and Entrepreneurship Through Design

In the *United Kingdom* a secondary school, John Cabot Technical College, established a unique company called CTC Plus, which has the students work on industrial projects after learning design. These projects include such things as manufacture of parts, prototypes and products for local engineering companies. Students run the business with guidance and support from their teacher. The goal is to have the students learn business and management skills needed to successfully engineer a product that meets the customer's requirements. These UK secondary students won a

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[9] Passey, D., et.al., *The Motivational Effect of ICT on Pupils*, Department for Education and Skills, London, 2004, P. 28

[10] Passey, *The Motivational Effect of ICT on Pupils* (Executive Summary), 2004, p. 5

[11] Ibid., P.6

[12] Report from the Office of Her Majesty's Chief Inspector of Schools entitled: *ICT in Schools: Effect of Government Initiatives: Secondary Design and Technology,* 2002, p. 4

[13] Hodgson, T. & C. Allsop "Beyond Pro/DESKTOP Computer Aided Design (CAD): the transfer of CAD-based design modelling skills from schools to Higher Education", Department of Design and Technology, Loughborough University, UK, 2002, P. 7

Rolls Royce contract to design a maintenance tool for the Pegasus Engine used in the Harrier Jets. The student's design components will be sold to the US Marines and the UK military. The students got 50% of the proceeds of the contract and 50% went to the school's academic program. Each year's revenue finances the education for the next year's students.[14]
The Real World Design Challenge "bridges the needs of industry with the future of education." It teaches innovation, creativity, and collaboration using the expertise that industry has been perfecting for decades. With this real world approach to learning, we can keep our workforce strong, and ensure America's prosperity for the future.

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Real World Design Challenge Process:

What Schools Get:

1. Training

- Training Description: Teachers will be trained in design, in a two day workshop in which they will learn how to use Pro/ENGINEER and other tools and learn how to apply these tools in teaching design and global engineering. Training in the use of Windchill ProjectLink, the Global Engineering collaboration tool will be done in a web-based workshop subsequent to the design workshop. Participants will access the Windchill ProjectLink training using a computer connected to the Internet and a phone.

- Training Costs: Teacher training costs are normally between $200 and $300 for all the training. Fees are negotiated with independent, PTC certified trainers. PTC will provide the state or district with a list of trainers. They will then arrange mutually agreeable dates, fees and travel support with the trainer. All software tools and curriculum materials will be provided for FREE.

[14] Interview with Nathan Green, Head of the Technology Centre, John Cabot Technical College, Kingswood, UK, March, 2004. Also, "Teenage aero engineers win flying start" *Daily Press,* February 24, 2004; "Teenagers win R-R deal to equip the US Marines", *Evening Post,* February 24, 2004

- Training Site(s): States or districts will need to identify a computer lab at a school or institution of higher education for the training site. These are typically provided as an in-kind contribution by the hosting organization. The Design training will be done in a computer lab. The computer lab will need to have at least fifteen PCs with Internet access. Each participant will need to use a computer in the training since they will have a great deal of hands-on experience and individual instruction by certified trainers.

2. Science and Engineering Mentors

Student teams and mentors use professional tools to collaborate across the Internet. Mentors provide advice on science and engineering content and approaches. Mentors infuse professional science and engineering expertise in the classroom to support professional development for teachers and student learning. The mentors are also professional role models enabling students to gain a sound understanding of professional STEM roles through modeling and practical application.

- DOE Energy Laboratories: The laboratories infuse rare scientific and engineering expertise into the classroom. Science and engineering mentors from the 17 Department of Energy National Laboratories will provide advice on basic science, math and engineering principles and approaches.

- Industry and the Federal Aviation Administration (FAA): Engineering mentors from industry and the FAA will provide expertise on aviation engineering.

3. Real Problem

- Aviation Challenge defined by industry: Cessna engineers have defined a Challenge that is currently being addressed by the aviation industry. After learning the basics of design, teachers and students will be challenged to come up with innovative solutions to the Challenge. Classroom experiences build capacity and teach students to work as global engineering teams. The Challenge will be issued to participating teams in the fall of 2008. Topics increase in sophistication from the Governor's Challenge to the National Challenge. School teams across the state will compete to solve the Governor's Challenge. The Challenge submissions will evaluated by a Peer Review Committee. All participating teams will be invited to an awards ceremony hosted by the Governor at which the wining team will be announced. That team will go on to represent the state at the National Challenge in Washington, DC.

- Developmentally appropriate for high school students: Educators working with the Cessna engineers have helped design the Challenge to ensure that it is developmentally appropriate for high school students and addresses national standards in science, mathematics and technology.

4. Real Tools

- Pro/ENGINEER Schools Edition 3D Computer Aided Design (CAD) software: Pro/ENGINEER is 3D CAD parametric design software, created by PTC, and provides solid modeling, assembly modeling and drafting functionality for engineers and designers. Pro/ENGINEER enables students to quickly and easily create complex 3D models, assemblies and 2D measured drawings, and was the first tool to introduce the concept of Parametric Modeling. Attributes of features within the model are 'parameterized', which means that any changes made to a design are automatically disseminated to all facets of the model – enabling students to design with confidence. Each teacher gets FREE licenses of Pro/ENGINEER Wildfire design software (up to 300 seats), project based curriculum and

tutorials. Teachers are encouraged to have students install Pro/ENGINEER at home. All that is required to receive the software and curriculum materials is that teachers attend a workshop. All workshops are taught by fellow teachers that have been certified as instructors by PTC. Each license of Pro/ENGINEER is worth $3,000, since each teacher will receive 300 licenses that is a **donation of $900,000 per teacher.**

- Windchill Global Engineering collaboration software: Times have changed radically in global manufacturing! Due to global outsourcing, the days of professional engineering teams designing 'shoulder-to-shoulder'–working on 3D designs in isolation– are over. Likewise, the days of student engineers designing alone in isolated classrooms are also ancient history. To ensure their success in the real world, it is imperative that future engineers learn to design and build next-generation products in cooperation with other engineers, who don't just live across campus, but across states and nations. Today, PTC is the only company that offers the "Global Engineering" initiative for education. PTC couples Pro/ENGINEER with the global engineering solution–Windchill ProjectLink – a project-based collaboration tool that students access through the Internet. Working within Windchill ProjectLink's virtual workspace, teams of student designers – situated anywhere in the world – can access up-to-the minute data pertaining to their project. Windchill offers powerful tools for storing, managing and sharing 3D design and project data, while also providing discussion forums and real-time meeting capabilities. Team members can exchange ideas, build off each other's input, and capture innovative ideas as they evolve in real-time. Plus, Students have the opportunity to collaborate on "real-world" design challenges with 'real-world' professionals. Windchill is web-based and will be hosted by Oakridge National Laboratory. Schools will access it using a computer and the web. It will be FREE to participants. The commercial value of Windchill ProjectLink is $2,800 per seat. **Each school team will get seven seats worth $19,600.** If the school fields more than one team the donation will be higher multiplied by the number of teams.

- Engineering Fluid Dynamics (EFD) is a new breed of Computational Fluid Dynamics (CFD) software produced by Flomerics, Inc. This fluid dynamics simulation software enables mechanical engineers to simulate fluid flow and heat transfer using 3D CAD models. EFD.Pro has been integrated with Pro/ENGINEER and will work with native geometry. Since EFD.Pro is integrated into Pro/ENGINEER it has a similar same "look and feel". This minimizes the learning curve on learn a new application to operate the software and can therefore focus on solving your problem. Each participating school will be provided with one license of EFD.Pro for FREE. **The commercial value of EFD.Pro is $24,500.** Each school team will get one license. If the school fields more than one team the donation will be higher multiplied by the number if teams.

5. Real Roles

- Student teams are built around real industry roles such as project manager, scientist, engineer, and community relations & marketing.

6. Real Contribution

- Contribute innovative solutions to real industry design problems. Student teams will be recognized by professionals in industry and government for their contribution to solving current design problems. Teams that win The Governor's Challenge at the state level will go on the Washington, DC to compete at the National Challenge. **The US Department of Energy will provide travel support for the winning teams travel to Washington, DC.** The team that wins the National Challenge will be recognized by leaders in government and industry.

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